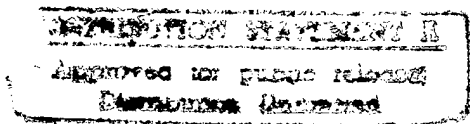Quarterly Status Report No. 8
Report Period: May 1, 1996, through July 31, 1996
Submittal Date: August 15, 1996

CT-ASSISTED SOLID
FREEFORM FABRICATION

Prepared by:

James H. Stanley
Principal Investigator

DTIC QUALITY INSPECTED 4

Prepared for:

Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5660
Attention: Dr. Steven G. Fishman

19970513 041

Reference:

Contract Number N00014-94-C-0120
ARACOR Project Number 920

1.0   INTRODUCTION

Computed Tomography (CT) is a radiographic inspection method that uses a computer to reconstruct a cross-sectional image of an object from a set of in-line X-ray transmission measurements. CT was introduced in the early 1970's as a neurological examination technique and later extended to industrial applications by Advanced Research and Applications Corporation (ARACOR) and others. The original medical acronym, CAT, is still widely used and is likely to be familiar to the reader. The technology provides an ideal examination technique whenever the primary goal is to locate and size planar or volumetric detail in three dimensions. Because of the relatively good penetrability of X rays, as well as the sensitivity of absorption cross sections to the density and atomic number of matter, CT permits the nondestructive physical and, to a limited extent, chemical characterization of the internal nature of objects. And since the method is X-ray based, it applies equally well to metallic and non-metallic specimens, solid and fibrous materials, smooth and irregularly surfaced parts.

A key advantage of CT is that it can nondestructively obtain images of both exterior and interior surfaces and regions of an object. Because CT images are densitometrically accurate, complete morphological and part characterization information can be obtained without need for physical sectioning. With CT, complete 100% examinations can be obtained in a few hours, independent of part complexity. The data can be processed to create CAD representations of the part, to extract dimensional measurements, or to detect, size and locate defects. Current industrial CT systems have progressed to the point where they can provide dimensional measurements of a part with accuracies competitive with coordinate measuring machines (CMMs). However, unlike CMMs, CT systems can obtain thousands of measurements simultaneously, without special pre-programming, of internal as well as external surfaces, while also detecting flaws and defects. And because CT images are digital, they can be enhanced, analyzed, compressed, archived, retrieved, input to engineering calculations, and transmitted intramurally via local area network (LAN) or extramurally via the information super-highway.

As a result of these advantages, CT has emerged in the last few years as the leading modality for reverse engineering and part characterization applications. In 1988, the Air Force Wright Laboratory (WL) sponsored a Boeing-ARACOR team to investigate potential industrial applications of CT. Of the dozen or so generic application areas studied, the use of CT for reverse engineering and part characterization was ranked as the top commercially viable use. The WL technical report, "X-Ray Computed Tomography for Casting Development" (WL-TR-92-4032), concluded that "areas which would benefit [from the use of CT] include internal dimensional

measurements (eliminating destructive sectioning), specific region inspections, flaw characterization in critical regions (to allow passing or informed repair of castings), and geometric acquisition for CAD/CAM."

Like casting production, solid freeform fabrication (SFF) is also a near-net-shape technology. Thus, the above conclusions are as applicable to SFF practices as to castings. A model of the relationship between CT and SFF is presented in the figure. As illustrated, CT can be used to create "virtual objects" from existing objects. The process of scanning a part, extracting part contours from a CT image, and converting the data to a CAD-compatible format is commonly referred to as CT-assisted reverse engineering. Conversely, when a part is fabricated from a CAD model, CT can be used to nondestructively examine (NDE) the end product. The process of CT scanning a part, extracting defect and dimensional data from an image, and generating a variance report is commonly referred to as CT-assisted part characterization. Together, CT-assisted reverse engineering and part characterization form a complementary pair. Both are essential elements of a powerful dynamic with the ability to drive and accelerate the development of SFF equipment, methods and processes.
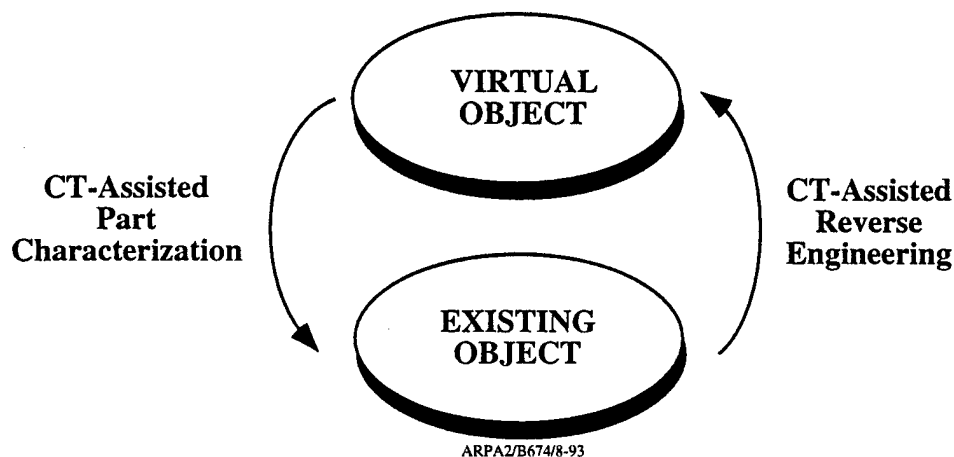
CT-Assisted Solid Freeform Fabrication.

2.0 PROGRAM OBJECTIVES

In response to the Advanced Research Projects Agency (ARPA) Broad Area Announcement (BAA) 93-24, "Solid Freeform Manufacturing," ARACOR successfully proposed the development and demonstration of CT-assisted solid-freeform fabrication practices. The project will provide critical reverse engineering and part characterization functions common to all ARPA-sponsored SFF activities. The goal is to facilitate the timely transition of CT-assisted reverse-

2

engineering, dimensional verification and defect detection practices to the SFF community. To meet this goal, the following major technical objectives have been established:

- *Develop application software to make CT-assisted manufacturing practices available to the SFF community.* The application will run on a variety of common workstation platforms, accept data from different CT scanners, and output results in various formats to facilitate reverse engineering, dimensional verification and report generation. The SFF software tools will be derived from existing capabilities previously developed for the investment casting industry and from capabilities defined during interactions with other BAA participants.

- *Provide the SFF community access to CT-assisted reverse engineering, dimensional verification, and defect detection services.* Through ARPA, BAA participants will be able to request access to CT scan and analysis services. Access to high-resolution ($< 25\mu$) CT scans will be provided for structural ceramics and other composites needing high-definition nondestructive evaluation (NDE) imaging, and access to high-energy (~9 MV) CT scans will be provided for metallic and other components needing large-structure NDE imaging. CAD, dimensional and defect information will be extracted from image data by ARACOR and provided to other BAA participants.

- *Transfer CT-assisted manufacturing practices to the SFF industry by beta siting application software and training users in its operation.* The SFF application software will be installed at beta-site locations designated by ARPA and recipients instructed in its use. As directed by ARPA, ARACOR staff will travel to BAA participant sites to demonstrate the extraction and analysis of CT-derived data with the proposed SFF application software.

3.0 WORK PLAN

The Work Breakdown Structure (WBS) for the above activities comprises the following three technical and one management tasks:

Task 1. Develop CT-Assisted SFF Software Application. ARACOR shall develop a software package to make CT-assisted SFF manufacturing practices universally accessible to system-level designers. First, ARACOR shall integrate existing ARACOR reverse engineering and dimensional verification tools into a pre-commercial version of a software application that can run on a variety of common workstations (WBS 1.1). At a minimum, versions which run on Silicon Graphics, Sun and IBM workstations will be developed. Following that, ARACOR shall develop and integrate advanced analysis tools specially for composites produced by SFF techniques into the application (WBS 1.2). The application will allow users to input CT data from a variety of CT

3

systems and output results in formats suitable for reverse engineering, dimensional verification and report generation purposes. The application will feature an intuitive graphical user interface and networking capabilities for transferring data between workstations. Task 1 will run through years 1 and 2 and will be complete when the beta-site version of the application is ready for release.

Task 2. Provide Access to CT-Assisted Manufacturing Services. ARACOR shall provide CT-assisted reverse engineering (WBS 2.1), dimensional verification (WBS 2.2) and defect detection (WBS 2.3) services to the SFF community. Access to high-resolution and high-energy CT scan services are included. The work plan proposes that all requests for services will be directed to and approved by ARPA. The work plan assumes that the demand for analysis services will concentrate in the first two years while the SFF application software is being developed and will decrease during the third year once other BAA participants are provided beta-site versions of the necessary CT software tools (see Task 3). The work plan also assumes that scan services will be provided throughout the three-year SFF program to support third-year technology insertion efforts. Task 2 will be complete when the level of effort budgeted for these services has been expended.

Task 3. Transition CT-Assisted Practices to Industry. ARACOR shall install the software application at beta sites specified by ARPA and train participants in the use of CT-assisted SFF practices (WBS 3.0). Up to three beta-site locations for the application may be selected. The work plan proposes that CT scan data be provided as part of Task 2 and that ARACOR travel to participant sites to provide on-site training and assistance in the application of CT-assisted flaw detection, dimensional verification and reverse engineering practices. At ARPA's direction, ARACOR will provide up to twelve trips for staff specialists to BAA participant sites to assist with the analysis of the scan data and to train designers in the use of the software. This will have the added benefit of providing ARACOR direct pre-commercial-release feedback from the SFF industry about the performance of the product. Task 3 will run during the third year and will be complete when the level of effort budgeted for these activities has been expended.

Task 4. Manage Program and Prepare Reports. ARACOR shall provide program management (WBS 4.1) for the duration of the contract and shall satisfy the contract data requirements list (CDRL) associated with the program. In particular, ARACOR will submit Quarterly Progress reports (WBS 4.2) and a Final Report (WBS 4.3) in the company's standard format. The sole deliverables associated with this program are beta versions of the software application, the quarterly Progress Reports, and the Final Report.

4.0 EXECUTIVE SUMMARY FOR REPORT PERIOD

- The development of ARCHIMEDES v1.0 was completed (WBS 1.1).
- The development of ARCHIMEDES v2.0 continued on schedule (WBS 1.2).
- The first beta test site was established at Marshall Space Flight Center (WBS 3.0).
- The PI attended a SFF program review on May 29-30 (WBS 4.1).
- The seventh quarterly report was submitted (WBS 4.2).

5.0 TECHNICAL DISCUSSION

Task 1.1. ARCHIMEDES v1.0

The development of ARCHIMEDES v1.0 has been completed. A beta version of ARCHIMEDES 1.0 has been frozen in ARACOR's configuration management system. To date, we have placed five beta copies for evaluation with General Electric Aircraft Engines of Cincinnati, OH; Howmet Corporation's Advanced Technology Department in Whitehall, MI; Imageware Corporation of Ann Arbor, MI; NASA Marshall Space Flight Center of Huntsville, AL; and Volkswagen AG Corporation of Wolfsburg, Germany. We are following up with other potential beta evaluators who have expressed an interest in the product.

Task 1.2. ARCHIMEDES v2.0

We are in the design and development phase of Version 2.0.

Task 1.2.0, System Design, is complete. Under this task, we created a detailed functional specification of ARCHIMEDES 2.0. All new data viewers, menu bars, and dialog boxes were specified. In addition, design of new Graphical User Interface (GUI) classes and re-design of existing ones were done.

Task 1.2.1, Constituent Module, which will add a low-contrast segmentation capability, is expected to begin in October 1996.

Task 1.2.2, Metrology Module, which will add a variety of mensuration tools to ARCHIMEDES, is expected to begin in August 1996. Tools will be included to measure distance, length of curves, surface area, etc.

Task 1.2.3, Porosity Module, which will add a low-contrast classification capability, will begin in September 1996.

Task 1.2.4, Reinforcement Module, which will add a variety of statistical tools to ARCHIMEDES, will begin in September 1996. Tools will be included to measure standard deviation, error in the mean, histograms, cumulative histograms, and second-order statistics.

Task 1.2.5, Convert to NURBS, which will convert contour representations to NURBS (Non-Uniform Rational B Splines) format, will begin in September, 1996. This will expedite the process of creating surface models in Surfacer.

Task 1.2.6, Write SLC Files, which will provide the capability to create 2-D contours from a 3-D mesh and write them in SLC format, will begin in November 1996.

Task 1.2.7, Read/Display NURBS/IGES, which will provide the ability to read CAD files in the IGES format, has begun. It is expected to be completed in September 1996. We have decided to purchase and use the third-party software library, PDE/Lib from ITI of Millford, OH, to read the IGES format files. The surfaces and curves which are read using this library will then be in a form suitable to display and analysis in ARCHIMEDES.

Task 1.2.8, Point Comparison with CAD Models, which will provide the ability to compare a point cloud generated from contours or meshes with an existing CAD model, will begin in September 1996.

Task 1.2.9, Develop Automatic Segmentation, has been discontinued due to the fact that other tasks were deemed to be of higher priority.

Task 1.2.10, Handle Large Data Sets, is 90% complete. We can now read in and process arbitrarily large data sets without requiring arbitrarily large amounts of memory. Ten C++ classes were created for the purpose of providing dynamic access of chunks of data from a disk file efficiently. The items that remain to be completed are the fine tuning of memory management parameters for optimal speed and the support of third-party data formats. This task is expected to be completed in September 1996.

Task 1.2.11, Slice Interpolation, will begin in December 1996. We plan to use a tensor product B-splines fit of the data, or a similar strategy to eliminate noise and to perform a sampling of the data at a finer discretization level.

Task 1.2.12, Decimate Meshes, is 70% complete. This capability provides a way to reduce the size of very large triangular mesh data without reducing accuracy. This is done by combining triangles that are coplanar to within a specified tolerance. We have created a new 3D viewer called the Model Viewer which will show the decimated or undecimated mesh, and the user will have control over the parameters which drive the decimation algorithm in an intuitive manner. What remains to be completed is the user interface dialogs and the superposition of other point data such as contour data on the image viewer. This task is expected to be completed in August 1996.

We have added the new Task 1.2.14, Add Medical Format, to our task list. It will enable the user to load volumetric medical images written in the American College of Radiology's DICOM

standard into ARCHIMEDES and use its visualization, segmentation, topology extraction and border creation capabilities. This task is expected to begin in January 1997.

Task 2. Manufacturing Services

No activity in this period.

Task 3. Technology Transfer

ARACOR's software manager traveled to NASA's Marshall Space Flight Center to set up the beta test site for ARCHIMEDES. Significant effort was required to prepare the software for distribution, write a tutorial, and develop training materials. The software was successfully installed and the users trained in its use. Follow-up calls suggest that NASA is using the software and is satisfied with its performance. Their feedback will be periodically solicited if not otherwise received.

Task 4. Management and Reporting

The PI traveled to Woods Hole, MA, for a program review on May 29-30. A summary of progress to date, as well as his take on the historical importance of SFF activities, was presented. It was well received by the other attendees, which included a large number of invited guests.

6.0 ANTICIPATED ACTIVITIES FOR NEXT REPORT PERIOD

- Beta-site testing of ARCHIMEDES v1.0 will continue.
- Development of ARCHIMEDES v2.0 will continue.
- Manufacturing services and technology transfer activities will continue as required.
- The next quarterly report will be prepared.

7.0 COST AND PERFORMANCE STATUS

Task 1.2 (ARCHIMEDES v2.0) is on schedule. Cost and schedule are running fairly close to forecast. Since the number of subtasks in Task 1.2 has been increased from 4 to 15, the project was re-baselined this quarter to facilitate program management. Unanticipated efficiencies in Task 1.2 will allow us to recover most of the cost overrun incurred on Task 1.1 (see Variance Reports). To cover the residual cost increase on Task 1, funds were reallocated among the various tasks, as reflected in the C/SSR.

Quarterly and cumulative man-hours and funds expenditure data, along with outstanding commitments, through the current reporting period are shown by task in Table A. The Program Schedule is shown in Figure A. The Funds Expenditure Graph, showing the planned-versus-actual total-dollar expenditures, is presented in Figure B. The Work Completed Graph, showing planned-versus-actual earned-value milestones completed, is presented in Figure C. Following that is the

Cost/Schedule Status Report (C/SSR). The percentage of total contract dollars that the expenditure to date represents and the percentage of total work that the technical completion represents are given in the C/SSR. Along with the C/SSR, variance analysis reports have been prepared for variances greater than 10% of the cumulative work scheduled. The Latest Revised Estimates (LREs) are generated as needed from a bottoms-up re-costing.

Table A. Current and Cumulative Expenditures.

Prime Contract: N00014-94-C-0120
Contract Award: $1,263,853
Authorized Funding: $770,803
Period of Performance: May 1, 1996, through July 31, 1996
Submission Date: August 15, 1996

WBS	Billings		Hours		Open Commitments
	Per.	Cum.	Per.	Cum.	
1. Software Development	66,225	$608,509	540	4,286.5	$0
2. Manufacturing Services	12,252	61,299	22	499.5	$0
3. Technology Transition	21,792	81,713	106	441.0	$0
4. Program Management	19,368	93,751	102	532.5	$0
Total	119,637	$845,272	770	5,759.5	$0
Contract Amount		$1,263,853		7,312	
Percent Complete		67%		79%	

Program Software Schedule

SOLID FREEFORM ARACOR Project 920

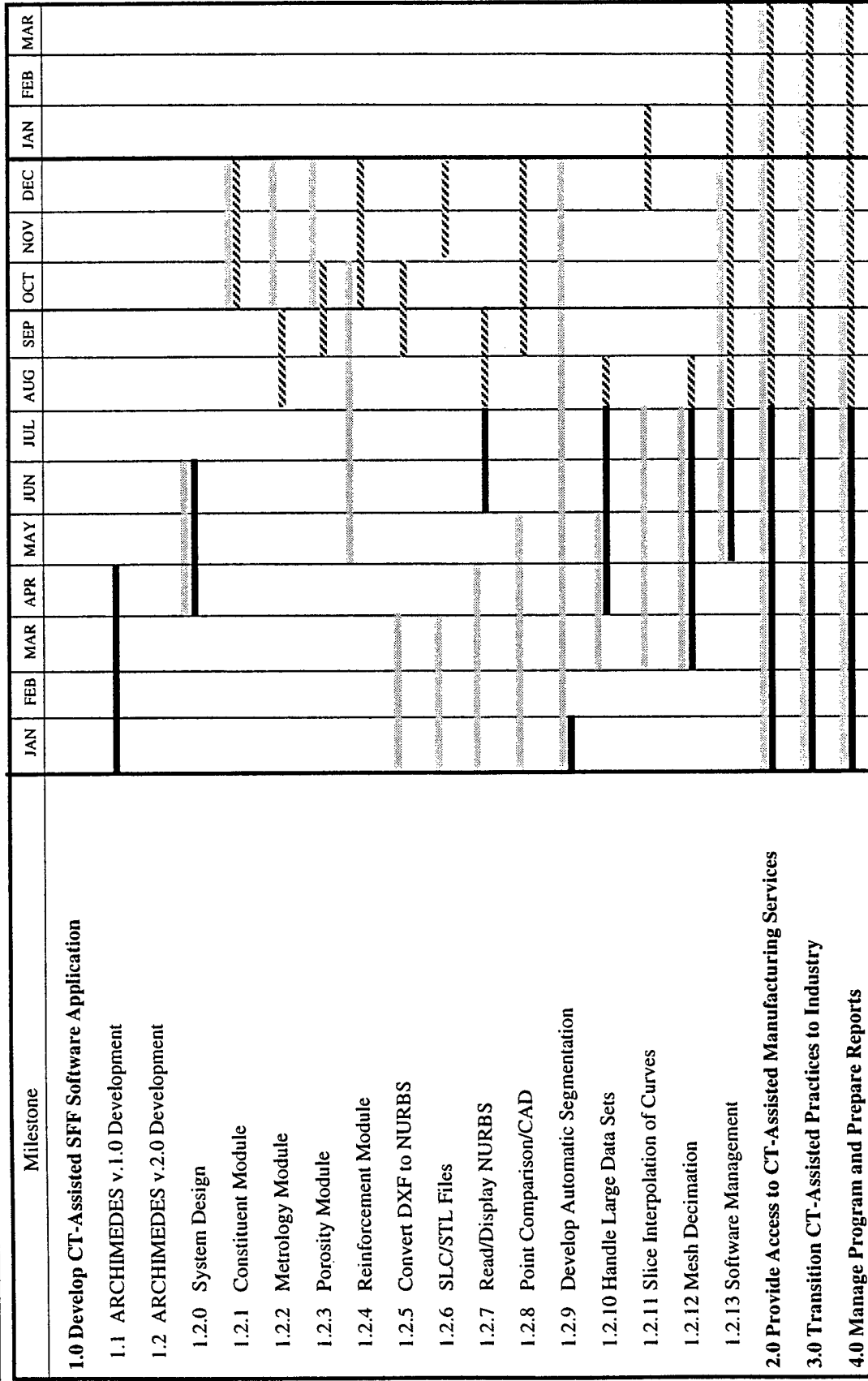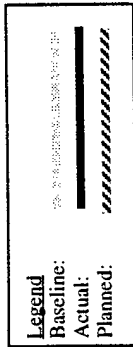| Milestone	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1.0 Develop CT-Assisted SFF Software Application															
1.1 ARCHIMEDES v.1.0 Development															
1.2 ARCHIMEDES v.2.0 Development															
1.2.0 System Design															
1.2.1 Constituent Module															
1.2.2 Metrology Module															
1.2.3 Porosity Module															
1.2.4 Reinforcement Module															
1.2.5 Convert DXF to NURBS															
1.2.6 SLC/STL Files															
1.2.7 Read/Display NURBS															
1.2.8 Point Comparison/CAD															
1.2.9 Develop Automatic Segmentation															
1.2.10 Handle Large Data Sets															
1.2.11 Slice Interpolation of Curves															
1.2.12 Mesh Decimation															
1.2.13 Software Management															
2.0 Provide Access to CT-Assisted Manufacturing Services															
3.0 Transition CT-Assisted Practices to Industry															
4.0 Manage Program and Prepare Reports															

1996 ◄──────► 1997

Figure A. Program Schedule.
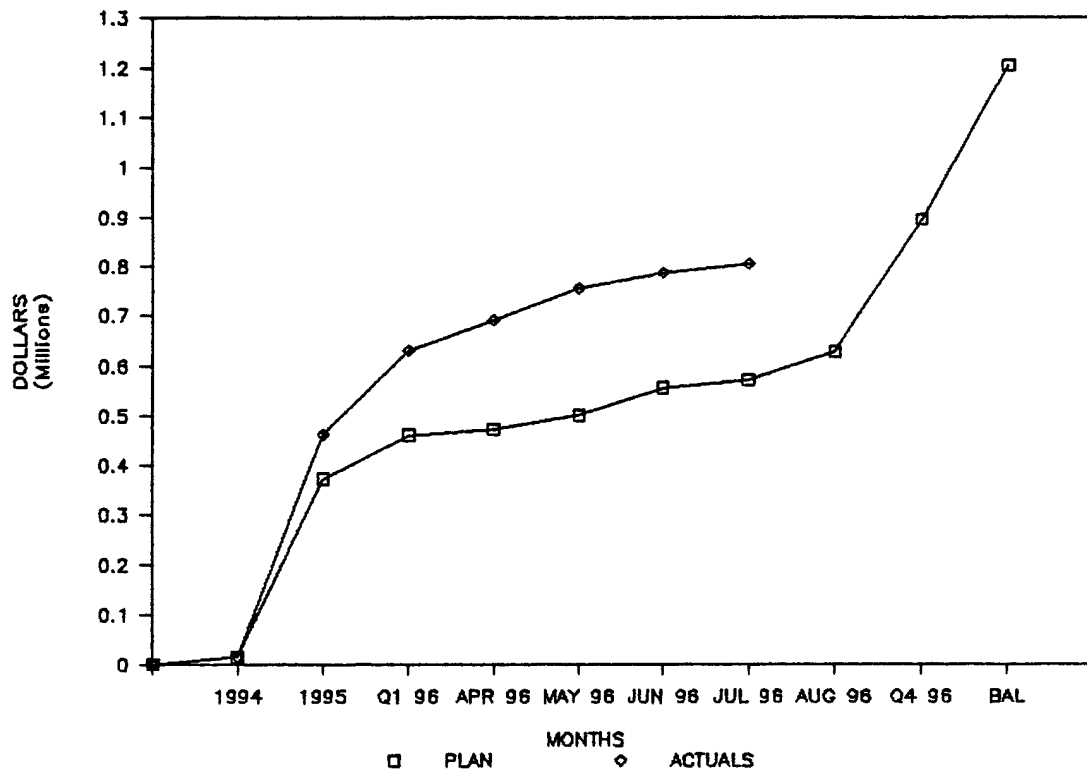
Figure B. Funds Expenditure Graph.
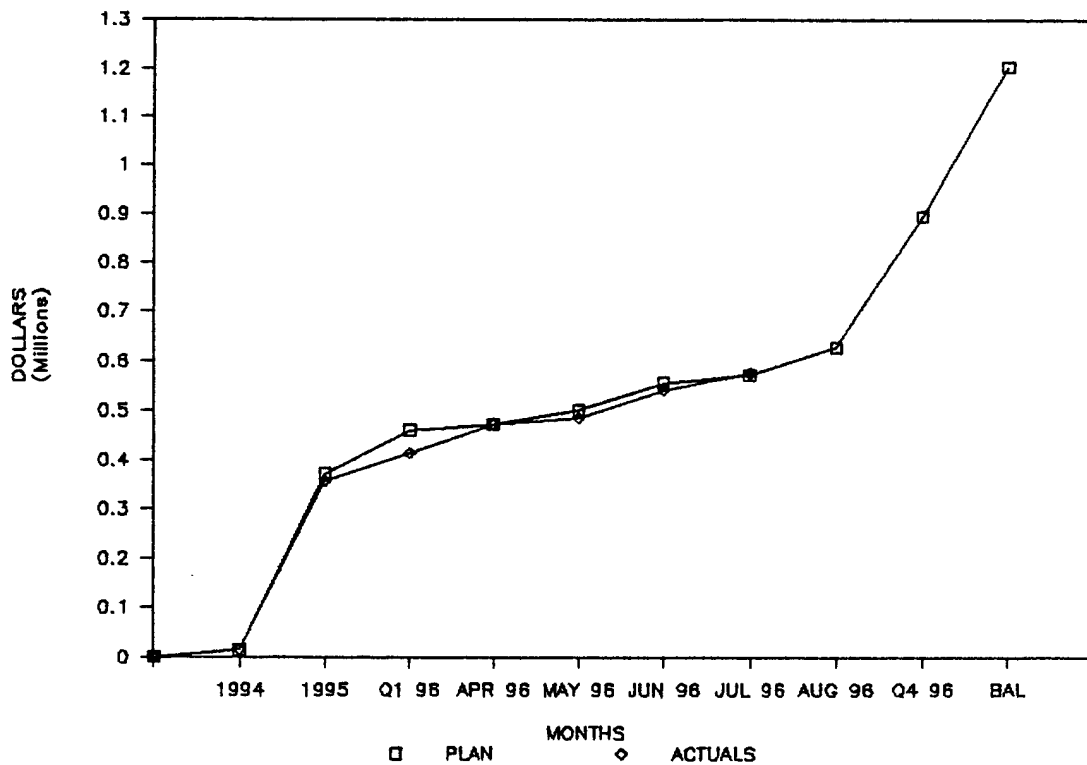
Figure C. Work Completed Graph.

COST/SCHEDULE STATUS REPORT

MONTH ENDING: JULY 1996
08/15/96

CT-ASSISTED SOLID FREEFORM MANUFACTURING
COST/SCHEDULE STATUS REPORT (C/SSR)

		CUMULATIVE TO DATE					AT COMPLETION			
	TECH COMP. %	BUDGETED COST		ACTUAL COST OF	VARIANCE			LATEST REVISED		FUNDS
TASK		WORK SCHEDULED	WORK PERFORMED	WORK PERFORMED	SCHEDULE	COST	BUDGETED	ESTIMATE	VARIANCE	REMAINING
1.0 SOFTWARE DEVELOPMENT	44%|	$366,042	$369,030	$587,335	$2,988	($218,305)	$764,685	$837,106	($72,421)	$249,771
2.0 MANUFACTURING SERVICES	52%|	$82,016	$82,016	$50,577	$0	$31,439	$196,000	$157,220	$38,780	$106,643
3.0 TECHNOLOGY TRANSFER	50%|	$44,660	$44,660	$77,822	$0	($33,162)	$89,320	$89,320	$0	$11,498
4.0 MANAGEMENT/REPORTING	52%|	$80,019	$80,019	$89,287	$0	($9,268)	$153,665	$153,665	$0	$64,378
TOTAL COST	48%|	$572,737	$575,725	$805,021	$2,988	($229,296)	$1,203,670	$1,237,311	($33,641)	$432,290
FEE				$40,251			$60,183	$60,183		
PRICE				$845,272			$1,263,853	$1,297,494		

CURRENT PERIOD COST AND PERFORMANCE

TASK NO.	CURRENT BCWS	CURRENT BCWP	CURRENT ACWP	SCHEDULE VARIANCE	COST VARIANCE
1.0	36,963	55,309	16,771	18,346	38,538
2.0	2,751	0	0	(2,751)	0
3.0	1,452	1,452	5	0	1,447
4.0	2,557	2,557	1,623	0	934
TOTAL	43,723	59,318	18,399	15,595	40,919

VARIANCE ANALYSIS REPORTS

TASK: Software Development

WBS: 1.0

Budgeted Cost of Work Scheduled	Budgeted Cost of Work Performed	Actual Cost of Work Performed	Cumulative Schedule Variance	Cumulative Cost Variance	Originally Budgeted Cost	Latest Revised Estimate
$366,042	$369,030	$587,335	$2,988	($218,305)	$764,685	$837,106

CAUSE OF SCHEDULE VARIANCE: Not material (less than 10%).

ANTICIPATED IMPACT OF SCHEDULE VARIANCE ON TASK: None.

PROPOSED CORRECTIVE ACTION: None.

LATEST REVISED SCHEDULE ESTIMATE: No change.

ANTICIPATED IMPACT OF SCHEDULE VARIANCE ON PROGRAM: None.

* * * * *

CAUSE OF COST VARIANCE: Task 1.1 was completed at a cost of $486,056, an increase of $209,869 over the amount originally budgeted for this task. The increase was not due to technical difficulties; rather it was due to the addition of essential unplanned work. The necessity for this extra work emerged as our understanding of the problem developed and the needs of the user became clearer. Despite the fact that the number of subtasks on Task 1.2 has been increased from 4 to 15, the latest revised estimate has been cut to $351,049, a decrease of $137,449 from the original amount budgeted for this effort. This efficiency is due in part to the work done in Task 1.1 to create a solid foundation for future development activities and in part to important synergisms with other programs that were not anticipated at the time of proposal. Thus, the net variance for Task 1 is ($72,421).

ANTICIPATED IMPACT OF COST VARIANCE ON TASK: This task will overrun unless unexpected efficiencies can be achieved.

PROPOSED CORRECTIVE ACTION: Remaining resources will be reallocated from Task 2 and possibly Task 4.

LATEST REVISED COST ESTIMATE: Task 1.2 was rebaselined this quarter to reflect the latest design analysis. The LRE is now $837,106, an increase of $27,368 from last time.

ANTICIPATED IMPACT OF COST VARIANCE ON PROGRAM: The redistribution of Tasks 2 and 4's dollars will lessen the level of effort associated with these secondary tasks but will have no impact on Task 1, the primary technical effort.

VARIANCE ANALYSIS REPORTS (CONTINUED)

TASK: Manufacturing Services   WBS: 2.0

Budgeted Cost of Work Scheduled	Budgeted Cost of Work Performed	Actual Cost of Work Performed	Cumulative Schedule Variance	Cumulative Cost Variance	Originally Budgeted Cost	Latest Revised Estimate
$82,016	$82,016	$50,577	$0	$31,439	$196,000	$157,220

CAUSE OF SCHEDULE VARIANCE: Not applicable; level of effort.

ANTICIPATED IMPACT OF SCHEDULE VARIANCE ON TASK: None. This task is not on any critical path.

PROPOSED CORRECTIVE ACTION: None.

LATEST REVISED SCHEDULE ESTIMATE: No change from last time.

ANTICIPATED IMPACT OF SCHEDULE VARIANCE ON PROGRAM: None.

* * * * *

CAUSE OF COST VARIANCE: Level of effort to date has been less than originally anticipated based on a straight-line projection of the budget allocated for this task. To date, only one part (the Harrier vane) has been reverse engineered.

ANTICIPATED IMPACT OF COST VARIANCE ON TASK: None.

PROPOSED CORRECTIVE ACTION: None.

LATEST REVISED COST ESTIMATE: No change from last time.

ANTICIPATED IMPACT OF COST VARIANCE ON PROGRAM: Unless efficiencies can be achieved on other tasks, the positive variance will be needed to cover overruns elsewhere in the program. It may even be necessary to reallocate some of the funds remaining.

VARIANCE ANALYSIS REPORTS (CONTINUED)

TASK: Technology Transition   WBS: 3.0

Budgeted Cost of Work Scheduled	Budgeted Cost of Work Performed	Actual Cost of Work Performed	Cumulative Schedule Variance	Cumulative Cost Variance	Originally Budgeted Cost	Latest Revised Estimate
$44,660	$44,660	$77,822	$0	($33,162)	$89,320	$89,320

CAUSE OF SCHEDULE VARIANCE: Not applicable; level of effort.

ANTICIPATED IMPACT OF SCHEDULE VARIANCE ON TASK: None. This task is not on any critical path.

PROPOSED CORRECTIVE ACTION: None.

LATEST REVISED SCHEDULE ESTIMATE: No change from original.

ANTICIPATED IMPACT OF SCHEDULE VARIANCE ON PROGRAM: None.

* * * * *

CAUSE OF COST VARIANCE: Level of effort to date has been more than originally anticipated based on a straight-line projection of the budget for this task. Costs had been running close to forecast, but the cost of setting up the first beta site this quarter was much greater than expected.

ANTICIPATED IMPACT OF COST VARIANCE ON TASK: Funds remaining (see C/SSR) may not be enough to complete everything we would like to do under this task.

PROPOSED CORRECTIVE ACTION: If necessary, funds will be reallocated to this task from Task 2.

LATEST REVISED COST ESTIMATE: No change at this time.

ANTICIPATED IMPACT OF COST VARIANCE ON PROGRAM: This level-of-effort task is secondary to the primary technical effort (Task 1). The only impact of the overrun will be to limit the number of technology transfer activities performed.

VARIANCE ANALYSIS REPORTS (CONTINUED)

TASK: Program Management   WBS: 4.0

Budgeted Cost of Work Scheduled	Budgeted Cost of Work Performed	Actual Cost of Work Performed	Cumulative Schedule Variance	Cumulative Cost Variance	Originally Budgeted Cost	Latest Revised Estimate
$80,019	$80,019	$89,287	$0	($9,268)	$153,665	$153,665

CAUSE OF SCHEDULE VARIANCE: Not applicable; level of effort.

ANTICIPATED IMPACT OF SCHEDULE VARIANCE ON TASK:

PROPOSED CORRECTIVE ACTION:

LATEST REVISED SCHEDULE ESTIMATE:

ANTICIPATED IMPACT OF SCHEDULE VARIANCE ON PROGRAM:

* * * * *

CAUSE OF COST VARIANCE: Management costs have been more than anticipated from straight-line projections.

ANTICIPATED IMPACT OF COST VARIANCE ON TASK: None. The variance is expect to correct itself with time.

PROPOSED CORRECTIVE ACTION: None.

LATEST REVISED COST ESTIMATE: No change from last time.

ANTICIPATED IMPACT OF COST VARIANCE ON PROGRAM: None.